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Abstract

Exploiting time series of the cost of a staples basket across 75 Russian regions over 1994-2000, price linkages of the regions are analyzed with the use of Granger causality as a tool. Price linkages of Russian regions are found extensive: on average, an individual regional market is linked through prices with 62% of others. Neither isolated clusters of regions nor autarkic regions are revealed; each region is linked with all others either directly or indirectly, through a chain of no more than two intermediate regions. Spatial autocorrelation is found to be widespread, taking place in two thirds of regions.

JEL classification: C22, P22, P23, R12.

Keywords: market integration, Granger causality, integration clubs, spatial autocorrelation

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NON-TECHNICAL SUMMARY

A spatially dispersed goods market can be defined as integrated if there are no barriers to trade among locations except for "natural," irremovable ones such as distances separating locations. A necessary condition for market to be integrated is occurrence of prices linkages across locations, so that a price shock in one location evokes responses in others. Thus, a pattern of inter-location price linkages complements a pattern of goods market integration obtained by other methods.

A tool for analyzing price linkages is Granger causality. The price of a good in one (first) location is said to be Granger caused by price in other (second) location if past values of price in the second location are significant in explanation of the current value of the first location's price. This paper analyzes price linkages across 75 (of all the 89) regions of Russia in 1994-2000, exploiting the above tool. The cost of a staples basket (relative to its cost for Russia as a whole) is used as a price representative.

Price linkages of Russian regions are found extensive. On average, an individual regional market is linked through prices with 62% of others, with the minimal number equaling 35%. Such a pattern corroborates the pattern of market integration obtained earlier, in which the most regions are integrated or tending to integration with the national market.

The pattern of price linkages sheds light on the issue of integration clubs. The integration club (an analog of convergence club in economic growth) is a group of regions that are not integrated or tending to integration with the national market, while being integrated or tending to integration with one another. Analyzing price linkages, neither isolated groups of regions nor autarkic regions are found. Price in each region is linked with prices in all others either directly or indirectly, through a chain of no more than two intermediate regions. This provides an evidence of absence of integration clubs in the Russian market.

A dependence of prices in a region on prices in adjacent regions implies spatial autocorrelation. It is found to be widespread, taking place in two thirds of regions. This fact should be taken into account while spatially modeling Russian market with the use of data on the cost of staples basket.

1. INTRODUCTION

A spatially dispersed goods market can be defined as integrated if there are no barriers to trade among its spatial segments (locations) except for "natural," irremovable ones such as physical distances separating locations. Provided that the market is integrated, prices across locations should be linked, so that a price shock in one location evokes responses in others. Sometimes, such linkages themselves are considered as an indication of market integration. However, price linkages are only a necessary condition for market integration, and not a sufficient one. Given an occurrence of price linkage between two locations, we can conclude nothing regarding the existence of trade barriers but that if they exist, they are not so high as to fully block trade between these locations. Nonetheless, an analysis of inter-location price linkages complements a pattern obtained through analyzing market integration as such, providing additional aspects of this pattern.

Analyzing Russia's market integration, Gluschenko (2006) divides regions of the country into three groups: (a) regions integrated with the national market over 1994-2000; (b) non-integrated regions tending toward integration with the national market; and (c) non-integrated regions that show no indication of an integrating trend. In such a pattern, however, the occurrence of "integration clubs" (an analog of convergence clubs in economic growth; see, e.g., Barro and Sala-i-Martin, 1995) remains an open question. Among regions that are not integrated (or/and not tending to integration) with the national market, there may be regions that are integrated (or/and tending to integration) with one another, so forming integration clubs and thus making integration of the Russian market to be fragmented. This paper aims to shed light on this issue. One more objective of the paper is to verify the above pattern of market integration, examining the extensiveness of inter-regional price linkages. At last, the effect of spatial lags is studied.

The empirical methodology is based on testing for Granger causality. The source data are time series of the cost of a staples basket across 75 regions of Russia for 1994-2000 with a monthly frequency. Using this methodology and data, no indications of integration clubs in the Russian goods market are revealed. Price linkages of Russian regions are found extensive: on average, an individual regional market is linked through prices with 62% of others. Thus, the pattern of price linkages is compatible with that of market integration, as the latter suggests that only 20% of Russian regions are not integrated with the national market and have no trend to integration, the reason for non-integration being, for the most part, a constant persistent difference in prices. Spatial autocorrelation is found to be widespread, taking place in two thirds of regions.

The analysis in this paper relates to studies by Goodwin, Grennes, and McCurdy (1999) and Berkowitz, DeJong, and Husted (1998), who also analyzed causal relationships between prices in the Russian market. The first paper uses data running from June of 1993 through December of 1994 with a weekly frequency and covering five cities and four individual goods. Both formal and informal ("gray") markets are considered. Goodwin et al. find extensive evidence of causality between prices across city formal markets, but weaker evidence for informal markets. The paper by Berkowitz et al. uses prices for five goods; their data run from February of 1992 through February of 1995 with a weekly frequency, covering 25 cities. They find greater evidence of causality between prices across the cities in their sample: the percentage of instances of causality varies across goods from 50.4% to 88.5%. This paper differs from the above ones, first of all, in the data. Covering most of Russian regions and spanning 1994-2000, it provides a comprehensive pattern of price linkages throughout the country over the period of improvements in market integration.

2. DATA AND METHODOLOGY

The price representative for the analysis is the cost of the basket of 25 basic food goods defined as the standard by the Russian statistical agency, Goskomstat, between January 1997 and June 2000 (see Goskomstat, 1996, p. 428, for a description of basket composition). This basket represents about one third of the food items in the Russian consumer price index (CPI) and, as calculated from data reported by de Masi and Koen (1995), 56.7% of the 1993 weights in the national CPI-food. The costs of the basket (including those for the second half of 2000 and retrospectively calculated for 1994-1996) were obtained directly from Goskomstat.

The price data were collected in capital cities of the Russian regions. The sample covers 75 of Russia's 89 regions. Data are lacking for ten autonomous *okrugs*, the Chechen Republic, and the Republic of Ingushetia. Two other regions are omitted. The City of Moscow is simultaneously an administratively distinct "city-region" of the Russian Federation and the capital city of the surrounding Moscow Oblast. The same holds for St. Petersburg and the Leningrad Oblast. That is why these cities-regions are present in the sample, while their surrounding *oblasts* are not. The data are monthly, spanning 84 months, from January of 1994 through December of 2000.

There are missing observations in the time series used. Most occur in 1994, which has 42 missing observations (4.7% of the yearly total) in 17 regional time series. The remainder of the data set lacks only 9 observations. To fill the gaps, missing values are approximated by the food component of the regional monthly CPIs. The interpolated value is the arithmetic mean of the nearest known preceding cost of the basket inflated to the required time point, and the nearest known succeeding cost deflated this point.

Let r and s index regions (r, s =1,…,R) and t indexes time (t = 0,…,T). The source price variable is the log relative cost of the basket, $P_{rt} = \ln(p_{rt}/p_{0t})$, where p_{rt} is the local cost of the basket and p_{0t} is the cost of the basket for Russia as a whole. To isolate price shocks, P_{rt} is cleaned of deterministic components through detrending and debreaking, producing P'_r as $P'_{rt} = \hat{\nu}_{rt}$, where $\hat{\nu}_{rt}$ is the estimate of residual in regression (across t = 0,…,T)

$$P_{rt} = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \alpha_3 B_{\theta rt} + \nu_{rt}. \tag{1}$$

The quadratic trend is taken to approximate nonlinear trends found in the time series; experiments with polynomials of different orders suggest that the second order is enough for such an approximation. The structural break is due to the August 1998 financial crisis in Russia. It is modeled by $B_{\theta rt} = 1$ if $t < \theta$, and zero otherwise. The break points, θ, are not uniform across regions, varying from 1998:08 through 1999:02. They are found by estimating (1) for θ = 1998:08,…,1999:02 for a given region, and then choosing θ that yields the least sum of squared residuals.

For each region pair (r, s), the following regressions are estimated across $t = l,\dots, T$:

$$\begin{aligned} P'_{rt} &= \varphi_{(r)0} + \varphi_{(r)1}P'_{r,t-1} + \dots + \varphi_{(r)l}P'_{r,t-l} + \psi_{(r)1}P'_{s,t-1} + \dots + \psi_{(r)l}P'_{s,t-l} + \varepsilon_{(r)t} \\ P'_{st} &= \varphi_{(s)0} + \varphi_{(s)1}P'_{s,t-1} + \dots + \varphi_{(s)l}P'_{s,t-l} + \psi_{(s)1}P'_{r,t-1} + \dots + \psi_{(s)l}P'_{r,t-l} + \varepsilon_{(s)t} \end{aligned}; \tag{2}$$

and the following hypotheses are tested: $H_{0(sr)}$: $\psi_{(r)1} = \dots = \psi_{(r)l} = 0$ (P'_s does not Granger cause P'_r) and $H_{0(rs)}$: $\psi_{(s)1} = \dots = \psi_{(s)l} = 0$ (P'_r does not Granger cause P'_s). Throughout the paper, the 10-percent significance level is accepted. Rejection of, say, $H_{0(sr)}$ implies a “causal” relationship among prices in r and s, the latter Granger causing the former. An interpretation is that a price shock in s at any point in time from $t-l,\ldots, t-1$ evokes response in r, so suggesting that there is a price linkage between these regions. A rejection of $H_{0(rs)}$ will be denoted as $r \to s$; that of $H_{0(sr)}$ will be denoted as $s \to r$ or $r \leftarrow s$; and joint rejection of $H_{0(rs)}$ and $H_{0(sr)}$, implying bi-directional causality or feedback, will be denoted as $r \leftrightarrow s$.

Having run the Granger causality test for all region pairs, the results can be summarized in an $R\times R$ matrix $\mathbf{C} = (C_{sr})$ such that $C_{sr} = 1$ if $r \to s$, and $C_{sr} = 0$ otherwise; $C_{rr} \equiv 1$. In fact, this is the adjacency matrix of a "causality graph" displaying direct price linkages between regions. If price in r does not affect price in s, but price in r affects price in q which, in turn, affects price in s, then regions r and s can be defined as linked indirectly ($C_{sr} = 0$, but $C_{sq} = 1$ and $C_{qr} = 1$). This definition is valid for any chain of intermediate regions instead of single q. An occurrence of indirect linkage between r and s implies that there is a path from r to s in the graph represented by $\mathbf{C}$. The $(R-1)$-th power of $\mathbf{C}$ provides a pattern of all direct and indirect price linkages; its zero rs-th element implies that there are neither direct nor indirect linkages between r and s. This pattern answers the question of whether the national market is fragmented to a few isolated submarkets. If rows and columns of $\mathbf{C}^{R-1}$ can be reordered so that it becomes a block diagonal matrix, then this is the case. A block represents an isolated submarket, regions in which have price linkages with one another, and no one is linked with a region beyond this submarket. It is such submarkets that can potentially be integration clubs. A one-element block is an autarkic regional market that has price linkages with no one other region.

In the spatial context, an analog of autocorrelation is possible (Anselin, 1988). As spatial autocorrelation can result in model misspecifications if it is ignored, it is important to reveal whether it takes place in the data under consideration. The notion of spatial lag is ambiguous, since, in contrast to time series, a "preceding" observation can be non-unique. As a rule, a spatial lag "$r-1$" for location r is constructed artificially from observations for contiguous locations. Here, a region's spatial lag, $P'_{\text{"}r\text{-}1\text{"},t}$, is a weighted average of prices in neighboring (from the standpoint of trade) regions: $P'_{\text{"}r\text{-}1\text{"},t} = \sum_{s=1}^{R}(w_{rs} / \sum_{q=1}^{R} w_{rq})P'_{st}$, where $w_{rs} = 1$ if s is a "trade neighbor" of r and zero otherwise; $v_{rr} \equiv 0$. Trade neighborhood takes account of actual communications between regions rather than their physical contiguity. For the most part, trade neighbors of a given region are, indeed, contiguous regions, but there are a number of exceptions. For example, the Kaliningrad Oblast, being an exclave, shares no common border with any other region of Russia. Saint Petersburg is taken as its trade neighbor. Another example is the Kamchatka and Magadan *oblasts* which share a common border, but no trade occurs through it. For the both, the Primorski Krai is taken as their trade neighbor, since deliveries of goods to these regions come through Vladivostok, the capital city of the Primorski Krai. To detect spatial autocorrelation, testing for Granger causality is applied as well. If "r – 1" $\rightarrow$ r, it is interpreted as evidence of spatial autocorrelation.

3. EMPIRICAL RESULTS

Before testing for Granger causality, the lags length, l, in (2) should be assigned. A conventional procedure of choosing it is to estimate (2) across a set of l and then to take a proper number basing on the Akaike or Schwarz criterion individually for each pair (r, s). Given 2775 pairs produced by 75 regions, such a procedure would be a daunting task. Therefore, a different way is exploited: regressions (2) are estimated and tested with l = 3, 6, and 12, and these results are compared across l. Table 1 compares some summary statistics of the results; and Table 2 repots correlation between results for different lag lengths. The numbers of instances of causality are those for a given region r; they are computed as follows. For $r \rightarrow s$, $N_{r\rightarrow} = \sum_{s=1}^{R} C_{sr} - 1$; for $r \leftarrow s$, $N_{r\leftarrow} = \sum_{s=1}^{R} C_{rs} - 1$; for $r \leftrightarrow s$, $N_{r\leftrightarrow} = \sum_{s=1}^{R} C_{rs} C_{sr} - 1$; the total number of causality instances is $N_r = N_{r\rightarrow} + N_{r\leftarrow} - N_{r\leftrightarrow}$. Figure 1 compares histograms of causality instances for l = 3, 6, and 12. Each plot in the figure combines all the three histograms for a given direction of causality. A histogram column in the plot for, say, $r \rightarrow s$ means the percentage of regions r with $N_{r\rightarrow}$ falling into a given interval.

Table 1. Summary statistics of results for different lag lengths

Statistic	Instances of causality (sum across s), percentage											
	$r \rightarrow s$			$r \leftarrow s$			$r \leftrightarrow s$			Total		
	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags
Minimum	13.5	10.8	9.5	9.5	9.5	6.8	1.4	1.4	0.0	29.7	35.1	16.2
Maximum	66.2	63.5	60.8	74.3	78.4	73.0	28.4	43.2	36.5	82.4	87.8	82.4
Mean	36.5	38.9	30.3	36.5	38.9	30.3	13.4	16.2	9.4	59.6	61.7	51.2

Table 2. Coefficients of correlation between results for different lag lengths

Correlation with results for	$r \to s$			$r \leftarrow s$			$r \leftrightarrow s$			Total causality		
	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags	3 lags	6 lags	12 lags
3 lags	–	0.79	0.48	–	0.71	0.23	–	0.68	0.36	–	0.82	0.52
6 lags	0.79	–	0.60	0.71	–	0.49	0.68	–	0.61	0.82	–	0.64
12 lags	0.48	0.60	–	0.23	0.49	–	0.36	0.61	–	0.52	0.64	–

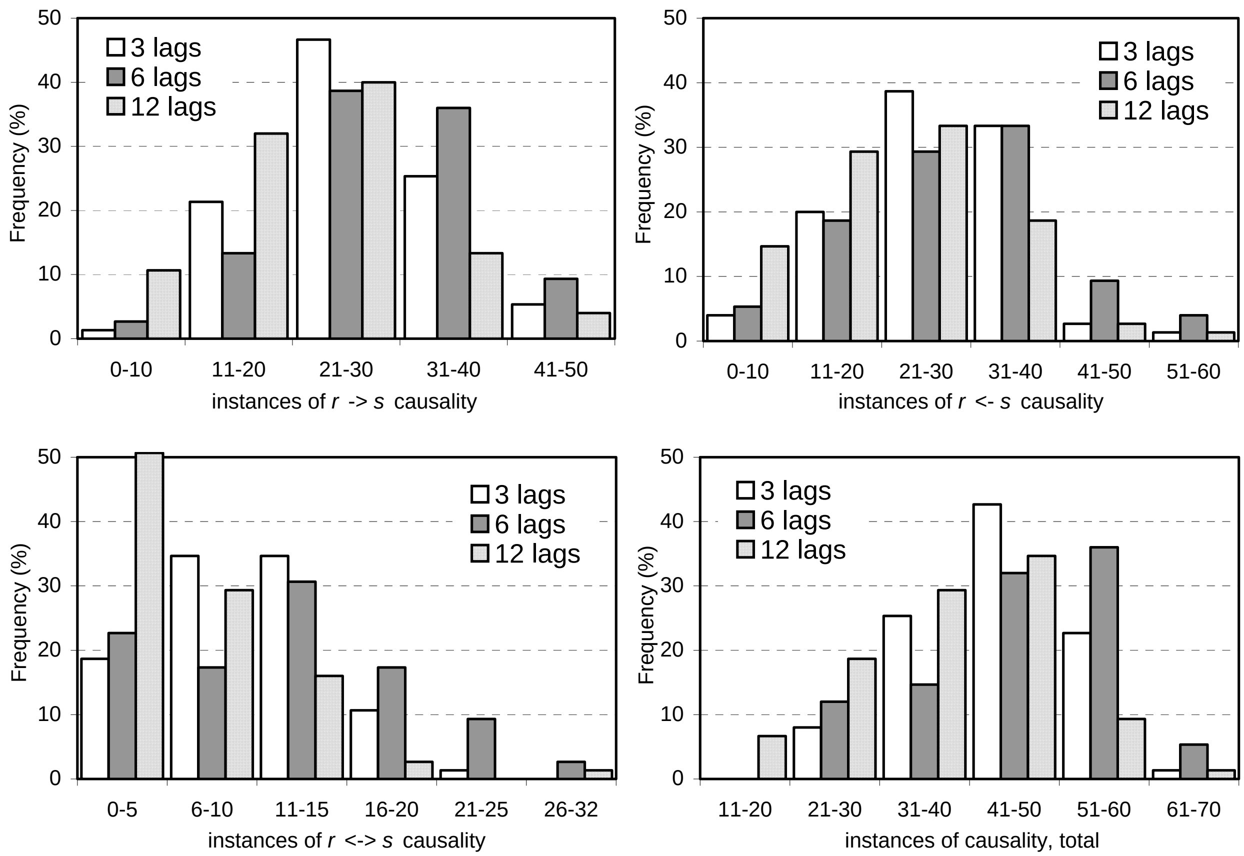

Figure 1. Histograms of results obtained with different lag lengths

By and large, the results for 3, 6, and 12 lags prove to be fairly similar, having no fundamental qualitative differences. As could be expected, additional lags increase detected instances of causality when *l* changes from 3 to 6. However, the loss in the degrees of freedom decreases detected instances of causality if 6 lags more are added. Thus, 6 lags seems to be a proper lag length. From the intuitive standpoint, a half-year delay is believed enough for evoking a response in the very distant regions of the country. From the statistical standpoint, such a loss in the degrees of freedom is reasonably small. Anyway, as the comparisons suggest, a deviation from optimal lag lengths cannot sufficiently distort the pattern of causality.

Table 3 summarizes results of testing for Granger causality for the baseline case of 6 lags. The second through fifth columns report $N_{r\rightarrow}$, $N_{r\leftarrow}$, $N_{r\leftrightarrow}$, and N_r, respectively, for a given region. The last column contains *p*-value of the null hypothesis that the spatially lagged price do not Granger cause the price in a given region, values above the critical significance level (of 10%) being marked with bold italics. The number of region's trade neighbors are in parentheses in this column.

Table 3. Results of Granger causality tests

Region *r*	**Instances of causality (sum across *s*), percentage**				**P(H$_{0(\text{"}r\text{–}1\text{"},r)}$)**
	$r \rightarrow s$	$r \leftarrow s$	$r \leftrightarrow s$	**Total**	
Rep. of Karelia	24.3	17.6	4.1	37.8	***0.545*** (2)
Rep. of Komi	52.7	48.6	25.7	75.7	0.026 (1)
Arkhangelsk Obl.	28.4	50.0	16.2	62.2	***0.103*** (2)
Vologda Obl.	24.3	45.9	14.9	55.4	0.058 (4)
Murmansk Obl.	41.9	52.7	17.6	77.0	0.076 (1)
Saint Petersburg	23.0	17.6	2.7	37.8	***0.603*** (5)
Novgorod Obl.	31.1	33.8	10.8	54.1	0.037 (3)
Pskov Obl.	16.2	31.1	5.4	41.9	***0.971*** (3)
Kaliningrad Obl.	20.3	20.3	1.4	39.2	***0.719*** (1)
Bryansk Obl.	25.7	24.3	8.1	41.9	0.021 (4)
Vladimir Obl.	27.0	16.2	8.1	35.1	***0.417*** (4)
Ivanovo Obl.	36.5	18.9	8.1	47.3	***0.302*** (4)
Kaluga Obl.	40.5	45.9	17.6	68.9	***0.851*** (4)
Kostroma Obl.	33.8	45.9	16.2	63.5	***0.109*** (4)
Moscow	29.7	12.2	5.4	36.5	***0.795*** (7)
Oryol Obl.	47.3	37.8	23.0	62.2	0.002 (4)
Ryazan Obl.	33.8	18.9	6.8	45.9	***0.862*** (7)
Smolensk Obl.	56.8	50.0	31.1	75.7	0.001 (4)
Tver Obl.	41.9	44.6	20.3	66.2	0.001 (4)
Tula Obl.	35.1	45.9	21.6	59.5	***0.117*** (5)
Yaroslavl Obl.	29.7	9.5	2.7	36.5	***0.851*** (4)
Rep. of Mariy El	45.9	47.3	17.6	75.7	0.003 (3)
Rep. of Mordovia	35.1	41.9	18.9	58.1	0.003 (5)
Chuvash Rep.	36.5	55.4	18.9	73.0	0.014 (5)
Kirov Obl.	41.9	20.3	10.8	51.4	***0.616*** (7)
Nizhni Novgorod Obl.	45.9	43.2	17.6	71.6	0.083 (5)
Belgorod Obl.	62.2	62.2	43.2	81.1	***0.444*** (1)
Voronezh Obl.	33.8	18.9	5.4	47.3	***0.514*** (6)
Kursk Obl.	62.2	31.1	18.9	74.3	***0.518*** (5)
Lipetsk Obl.	37.8	29.7	6.8	60.8	***0.292*** (6)
Tambov Obl.	35.1	47.3	21.6	60.8	0.015 (5)
Rep. of Kalmykia	35.1	24.3	2.7	56.8	***0.172*** (3)
Rep. of Tatarstan	54.1	43.2	20.3	77.0	***0.376*** (6)
Astrakhan Obl.	58.1	28.4	17.6	68.9	***0.597*** (3)
Volgograd Obl.	54.1	39.2	24.3	68.9	***0.311*** (5)

Region r	Instances of causality (sum across s), percentage				$P(H_{0(\text{“}r-1\text{”},r)})$
	$r \to s$	$r \leftarrow s$	$r \leftrightarrow s$	Total	
Penza Obl.	44.6	37.8	17.6	64.9	0.057 (5)
Samara Obl.	39.2	37.8	8.1	68.9	***0.200*** (4)
Saratov Obl.	48.6	68.9	29.7	87.8	0.007 (6)
Ulyanovsk Obl.	40.5	31.1	9.5	62.2	0.033 (6)
Rep. of Adygeya	31.1	12.2	5.4	37.8	0.050 (1)
Rep. of Dagestan	45.9	50.0	23.0	73.0	0.019 (2)
Kabardian-Balkar Rep.	33.8	40.5	17.6	56.8	***0.352*** (3)
Karachaev-Cirkassian Rep.	36.5	37.8	12.2	62.2	***0.132*** (3)
Rep. of Northern Ossetia	47.3	44.6	24.3	67.6	0.021 (2)
Krasnodar Krai	63.5	27.0	17.6	73.0	***0.914*** (4)
Stavropol Krai	37.8	40.5	13.5	64.9	***0.192*** (7)
Rostov Obl.	41.9	39.2	17.6	63.5	0.063 (4)
Rep. of Bashkortostan	48.6	44.6	18.9	74.3	***0.739*** (4)
Udmurt Rep.	37.8	31.1	9.5	59.5	***0.337*** (3)
Kurgan Obl.	29.7	59.5	21.6	67.6	***0.535*** (3)
Orenburg Obl.	44.6	73.0	35.1	82.4	***0.240*** (3)
Perm Obl.	20.3	31.1	6.8	44.6	***0.201*** (3)
Sverdlovsk Obl.	25.7	36.5	14.9	47.3	***0.211*** (5)
Chelyabinsk Obl.	47.3	52.7	23.0	77.0	***0.302*** (4)
Rep. of Altai	47.3	62.2	31.1	78.4	***0.172*** (1)
Altai Krai	48.6	36.5	17.6	67.6	0.052 (3)
Kemerovo Obl.	43.2	52.7	20.3	75.7	0.062 (5)
Novosibirsk Obl.	47.3	43.2	17.6	73.0	***0.560*** (4)
Omsk Obl.	29.7	41.9	8.1	63.5	***0.605*** (2)
Tomsk Obl.	29.7	23.0	8.1	44.6	***0.806*** (3)
Tyumen Obl.	43.2	52.7	24.3	71.6	0.005 (3)
Rep. of Buryatia	28.4	13.5	2.7	39.2	***0.551*** (2)
Rep. of Tuva	10.8	39.2	5.4	44.6	***0.232*** (2)
Rep. of Khakasia	45.9	58.1	32.4	71.6	***0.202*** (3)
Krasnoyarsk Krai	35.1	62.2	27.0	70.3	0.098 (5)
Irkutsk Obl.	12.2	27.0	1.4	37.8	***0.633*** (3)
Chita Obl.	32.4	48.6	20.3	60.8	0.002 (2)
Rep. of Sakha (Yakutia)	40.5	78.4	31.1	87.8	0.085 (1)
Jewish Autonomous Obl.	41.9	29.7	9.5	62.2	***0.123*** (2)
Primorsky Krai	47.3	14.9	6.8	55.4	***0.522*** (3)
Khabarovsk Krai	60.8	37.8	28.4	70.3	0.033 (4)
Amur Obl.	48.6	44.6	23.0	70.3	***0.119*** (3)
Kamchatka Obl.	14.9	41.9	6.8	50.0	***0.537*** (1)
Magadan Obl.	51.4	36.5	23.0	64.9	***0.110*** (1)
Sakhalin Obl.	58.1	59.5	33.8	83.8	0.002 (1)
Minimum	10.8	9.5	1.4	35.1	
Maximum	63.5	78.4	43.2	87.8	
Mean	38.9	38.9	16.2	61.7	

Matrix $\mathbf{C}^{R-1}$ has no one zero element, suggesting that there are neither isolated clusters of regions nor autarkic regions. Eventually, each region is linked with all others either directly or indirectly, through some chains of regions. In fact, three exponentiations prove sufficient for the matrix to have no zero elements; hence, each region is linked with any other through no more that two regions. Matrices $\mathbf{C}^{R-1}$ constructed from results of testing with 3 and 12 lags do not contain zero elements as well. This analysis provides an (indirect) evidence of absence of integration clubs in the Russian market.

Table 3 evidences that the extent of inter-regional price linkages is high: on average, price shocks are transmitted in either direction between a region and 46 other regions (or 62% of their total number). This number varies across regions from 26 regions (35%) to 65 regions (88%). There is a group of regions with the weakest price linkages (i.e., with the least N_r) with the rest of the country that is stable across lag lengths. It includes the Irkutsk and Vladimir *oblasts*. Such a group with the strongest linkages consists of the Republic of Sakha (Yakutia), and Saratov and Orenburg *oblasts*.

The range of $N_{r\rightarrow}$, the proportion of regions in which prices are Granger caused by price in *r*, is 11% to 64% (8 to 47 regions). The low-end group consists of the Republic of Tuva and Irkutsk Oblast. The Krasnodar and Khabarovsk *krais* belong to the high-end group. The proportion of regions that Granger cause price in *r*, $N_{r\leftarrow}$, varies across regions from 9% to 78% (7 to 58 regions). Moscow stably enters into the low-end group. The high-end group is not stable enough across lags lengths; however, the Republic of Yakutia is close to belong to it. The proportion of regions, prices in which are both Granger cause price in *r* and are caused by price in *r* (bi-directional linkages), $N_{r\leftrightarrow}$, varies from 1% to 43% (1 to 32 regions). The Irkutsk Oblast, Moscow, and Republic of Buryatia are the low-end group, and the Belgorod Oblast belongs to the high-end group.

Surprisingly, the extent of region's price linkages does not depend on whether it is, according to Gluschenko (2006), integrated with the national market, or tending to integration with it, or non-integrated. The averages over each of these three region groups are close to those over all regions: the group averages of $N_{r\rightarrow}$ fall in the range 31.2% to 36.2%; those of $N_{r\leftarrow}$ have the range 37.5% to 41.5%; the range is 15.7% to 16.8% for $N_{r\leftrightarrow}$; and the group averages of the total index, N_r, lie in the range 60.2% to 62.3%. One more surprising feature is a high extent of price linkages of difficult-to-access regions (remote regions with poor communications with the rest of Russia). These include the Murmansk, Magadan, Sakhalin, and Kamchatka *oblasts*, and the Republic of Yakutia. Their N_r equals 50.0% to 87.8%, the Republic of Yakutia having the maximal value across all Russian regions.

Gluschenko (2006) find 36% of Russian regions to be integrated with the national market, 44% of regions tending to integration with the national market, and 20% non-integrated with no trend toward integration. Among non-integrated regions, non-integration is almost entirely caused by a *constant* non-zero disparity between prices in a given region and the national price, and not by deterministic or stochastic price divergence; there are only two cases of price divergence. Such a pattern is corroborated by the above pattern of extensive price linkages in the Russian market.

The last column of Table 3 suggests widespread spatial autocorrelation. In almost than two thirds of regions (61.3% or 46 regions), prices are Granger caused by their spatial lags. A number of cases are of interest. Spatial autocorrelation is strongly rejected for Moscow City. This conforms with low value of its $N_{r\leftarrow}$, evidencing that the Moscow prices are weakly influenced by prices in other regions. On the other hand, the effect of Moscow prices on prices in other regions is not too wide: its $N_{r\rightarrow}$ is well below the average. It is worth noting that Moscow was found by Gluschenko (2006) neither integrated nor tending to integration with the national market. The same, although to a lesser degree, is valid for Saint Petersburg.

Prices in the Kamchatka and Magadan *oblasts* are not caused by those in the Primorski Krai, their only one trade neighbor, while being caused by prices in different regions. A possible explanation is that the Primorski Krai is, for the most part, a trans-shipment point for delivery of goods to these regions, and not a region of origin of the goods. The pattern is different for the rest three difficult-to-access regions (the Republic of Yakutia, Sakhalin and Murmansk *oblasts*) that have only one trade neighbor as well: spatial autocorrelation is not rejected for them.

4. CONCLUSIONS

Using the cost of basket of 25 basic food goods as the price representative, price linkages of Russian regions have been analyzed with the use of Granger causality as a tool. Price linkages of Russian regions are found extensive. On average, an individual regional market is linked through prices with 62% of others, with the minimal number equaling 35%. Such a pattern corroborates the pattern of market integration found by Gluschenko (2006), in which the most regions are integrated or tending to integration with the national market.

Neither isolated clusters of regions nor autarkic regions are found. Each region is linked with all others either directly or indirectly, through a chain of no more than two intermediate regions. This provides an evidence of absence of integration clubs in the Russian market.

Spatial autocorrelation is found to be widespread, taking place in two thirds of regions. Hence, to prevent a model misspecification, explicit account of spatial autocorrelation should be taken when constructing cross-sectional or panel models with the use of Russian regional price data.

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